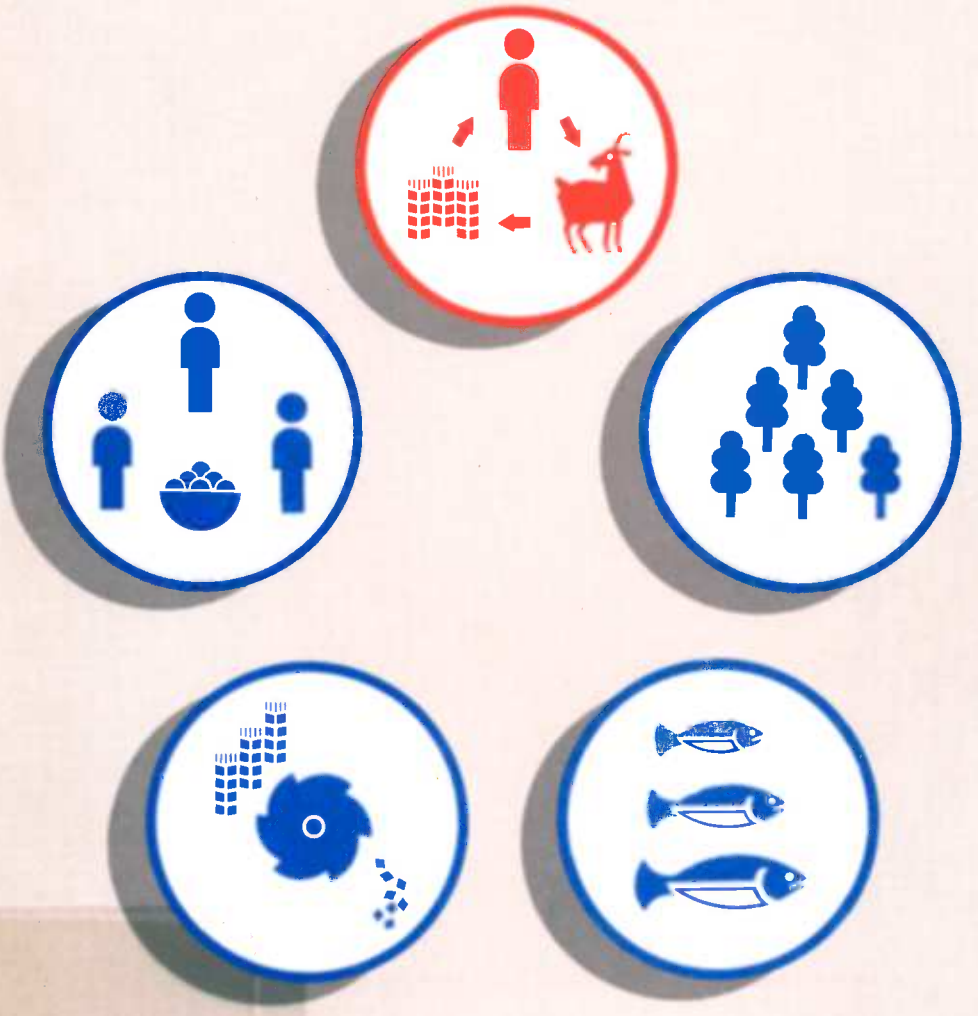
Agriculture, Food and
Nutrition Sciences

Crop and Animal Production Systems Program



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Il existe également une version française de cette publication.

La edición española de esta publicación tambien se encuentra disponible.

Crop and Animal Production Systems Program

Foreword

This booklet is intended to familiarize researchers and research-funding agencies with the scope of research supported by the Agriculture, Food and Nutrition Sciences Division of the International Development Research Centre (IDRC). It also provides information on how IDRC works with scientists in identifying research priorities and on the kind of support provided to researchers for developing and executing projects in the field of crop and animal production research.

In recent years, agricultural research has become increasingly international in scope, often with the participation of numerous institutions from several countries, each contributing its own particular expertise. At the same time, Canadian universities and research organizations have become increasingly interested in the agricultural problems of developing countries. As a result, these Canadian groups have strengthened the scientific capabilities needed to participate in the research efforts that are critical to ensuring sustainable agriculture and an equitable distribution of its products. We hope that this booklet will help to explain IDRC's role as a research-funding agency in this increasingly interconnected agricultural research environment.

The production of this booklet was a team effort by various IDRC staff members. The assistance of two people, in particular, is gratefully acknowledged: Geoffrey Hawtin, Associate Director responsible for IDRC's Crop and Animal Production Systems Program, and Liliana Wagner, Executive Scientific Assistant for the Division, who coordinated the writing of this series, which includes four other booklets

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The International Development Research Centre

The mission of the International Development Research Centre (IDRC) is to contribute to development through research and research-supporting activities. The Centre aims to assist in promoting the indigenously determined social and economic advancement of the developing regions of the world, with particular focus on the poorest people of those regions.

Within this mission, IDRC has two principal objectives: first, to support research of direct relevance to Third World development and having direct, demonstrable links to the basic needs of the poor; and, second, to assist developing countries to build indigenous research and research-supporting capacity, mainly at the national, but also at the regional, level and mainly in terms of human resources.

IDRC aims at these objectives by focusing its activities in six main areas: agriculture, food, and nutrition sciences; communications; earth and engineering sciences; health sciences; information sciences; and social sciences. IDRC also funds training in all these areas.

The Agriculture, Food and Nutrition Sciences Division

The world food situation is generally more positive than it was a decade ago. Food production is increasing at about 2.6% per year, slightly faster than the growth of the population but still below the increase in demand for food. More importantly, however, a considerable proportion of the world's population continues to receive much less than the minimal nutritional requirements. Technological innovation in food production has largely been concentrated in East Asia. Recent efforts to duplicate this achievement in Africa have been less successful because many of the prerequisites for success are not yet present there.

The Agriculture, Food and Nutrition Sciences (AFNS) Division's mission within the Centre is to contribute to agricultural development through specific research and research-supporting activities designed to make adequate food available to the individual and to improve the production, protection, preservation, processing, distribution, marketing, and utilization of agricultual commodities of plant and animal origin from land- or water-based systems, including forests. The scope includes the transformation of these commodities and the development of related industrial technologies to generate employment and income to enable people to purchase food. It also includes improving the use of land resources and protecting natural resources for future agricultural production.

The Division gives high priority to dissemination of research results and training of research staff in developing countries. On average, 2–5% of the project funds are now allocated to publications and dissemination workshops. Most AFNS projects contain a specific training component, which averages 10% of the project budget.

The Division's strategy is to support indigenous applied research carried out in close association with rural households, which make up 70% of the people in developing countries and who are to use and benefit from the research. Because effective research requires international linkages for evaluating germ plasm, exchanging information, training, and developing technology, AFNS also supports more advanced research in international and regional research centres, as long as such work is directly relevant and complementary to specific research projects or networks with national programs. Similarly, when Canadian institutions offer relevant expertise, the Division funds cooperative projects that are undertaken jointly by Third World and Canadian scientists.

AFNS supports research projects through five programs: Agricultural Economics, Crop and Animal Production Systems,

Fisheries, Forestry, and Post-Production Systems. This booklet reviews recent activities and outlines the future directions of the Crop and Animal Production Systems Program. Brief reviews of the other four AFNS programs begin on page 43.

The Crop and Animal Production Systems Program

Introduction

This booklet describes the objectives, strategies, and main research areas of the Crop and Animal Production Systems (CAPS) program of the AFNS Division. It provides an overview of the philosophy and activities of the program for those scientists, policymakers, and students throughout the world with whom CAPS interacts.

Program Objectives

The objective of the CAPS program is to improve the well-being of the rural poor in developing countries through support of research aimed at increasing crop and animal productivity and thereby enhancing incomes and helping to ensure access to sufficient food of good quality.

In accomplishing this objective, CAPS strives

- To achieve stable and sustainable agricultural productivity while maintaining environmental integrity;
- To encourage and support an equitable distribution of the benefits of research among the various sectors of society, particularly disadvantaged groups in the rural areas such as women, children, the aged, the landless, and minorities;
- To increase rural employment opportunities; and
- To reduce hazards to human health arising from factors such as the misuse of agrochemicals and toxic food constitutents.

Priority is given to research that will benefit the small-scale farmers who lack adequate land, water, financial, and other resources and who have been largely unaffected by the technological advances of recent years.

A primary objective of the Program is to reduce hunger and malnutrition in the Third World through focusing on its principal underlying cause, poverty. Increasing access to food and other basic necessities by the poor is given greater importance by CAPS than increasing agricultural productivity per se. Thus, although research aimed at increasing food production by smallholders is favoured, other nonfood commodities are also considered when they have the potential to alleviate rural poverty.

To achieve its objective, the Program also seeks to strengthen the indigenous research capability of scientists and institutions in developing countries. A strong national research capability is

essential if the continuing problems confronting agricultural development are to be adequately addressed. Training is an important element of projects supported by CAPS most of which extend over several phases and have an average life of 6–12 years.

Regionally, the CAPS Program gives priority to the semi-arid tropical areas, which are home to many of the world's poorest people who have benefited least from advances in agricultural technology. Large resources are devoted to sub-Saharan Africa, where per-capita food production is declining and research infrastructure is least developed.

Support to National Programs

The largest share of the budget is allocated to support research by scientists working in their own countries and national institutions. In most cases, scientists and other local staff are paid by the host institutions while CAPS funds purchase of some equipment, research operating costs, local and international travel, training, and consultancies. Only in exceptional cases will CAPS provide long-term expatriate advisors, preferring instead to strengthen local scientific talent.

CAPS supports the research of international and regional organizations if they are closely linked to research activities at the national level. Indeed, AFNS has taken a lead in establishing several international agricultural research organizations such as the

International Center for Agricultural Research In the Dry Areas (ICARDA) and the International Network for the Improvement of Banana and Plantain.

Networks

Projects supported by CAPS are often linked in networks in which researchers of the various component projects are encouraged to interact to their mutual advantage. Scientists from different countries of a network meet regularly to exchange ideas. In some cases, germ plasm may be exchanged between members of a network and cooperative research activities are encouraged.

Many networks have a full-time coordinator, often located at an international or regional research centre, who is responsible for arranging meetings and visits, providing advice and information, producing a newsletter, and planning other activities designed to promote collaboration among network members. The following are some of the wide range of networks supported, at least partially, by CAPS:

- The Asian Farming Systems Network, coordinated from the International Rice Research Institute (IRRI);
- The African Research Network for Agricultural By-products and the Pastures Network for Eastern and Southern Africa, both coordinated from the International Livestock Centre for Africa (ILCA);
- The Oilcrops Network for Eastern Africa and South Asia;
- The West African Farming Systems Research Network;
- The International Network for the Improvement of Banana and Plantain;
- The Latin American Animal Production Systems Network; and
- The Andean Potato Network coordinated from the International Potato Centre (CIP).

These and other networks are described more fully in later sections.

Cooperative Projects

CAPS attaches special importance to research that is likely to have an immediate impact at the farm level. Applied research, which often involves the target farming families themselves, receives the highest priority. More basic or strategic research is needed, however, to address particular problems that cannot be adequately tackled through applied field research. In such cases, there may be an advantage to linking the scientists in developing countries with their counterparts in Canada to make use of some of the special expertise and facilities available in Canada. About 20% of CAPS funds support such cooperative projects.

Examples of cooperative projects include research in some of the advanced biological techniques that are revolutionizing certain areas of agricultural research in the developed world. Projects already receiving CAPS support in this area include the use of electrophoretic protein–enzyme banding techniques for "fingerprinting" genotypes, production and use of haploid and double haploid plants of several tropical and subtropical plant species, induction and use of somaclonal variation, use of tissue culture for germ plasm storage and to produce virus-free genetic stocks, and studies of livestock karyotypes.

Small Grants

A typical CAPS research grant ranges from 50 to 100 000 CAD/year for the duration of the project. The program also supports small research activities that last less than 1 year. Student theses, exploratory research, and other limited-duration research on priority topics are funded in a flexible manner. Mechanisms are being developed to enable networks to allocate small grants to their members to encourage complementary and collaborative research judged to be of value to the network as a whole.

Funds are also provided by CAPS for meetings and workshops, usually on a regional basis and on high priority topics. In many cases, this includes publishing the proceedings of the workshop, often with support from IDRC's Communications Division.

Training

CAPS places a high priority on upgrading local research capabilities and allocates about 10% of most project funds for formal and informal training.

Many projects include a component for higher-degree training at either the master's or doctoral levels. Whenever possible, postgraduate students are supported for studies at universities in their own country or region, or elsewhere in the developing world. Such training is often associated with a regional or international agricultural research centre. This is more cost effective and, at the same time, strengthens local institutions of higher education. When students are registered in developed countries, arrangements are often made for thesis research to be conducted in the students' own country or region.

CAPS also works closely with the Fellowships and Awards Division of IDRC to help identify suitable candidates and institutions for higher-degree training.

The lack of well-qualified and experienced technicians is a major constraint to research in many parts of the world. Many CAPS projects, therefore, include a component for training technicians and junior scientists. The candidates take appropriate non-degree courses at international and regional research centres and,

in some cases, attend short courses conducted at the national level as part of project activities.

Many projects include training for extension workers and farmers. Farmer field days, publication of extension literature, and training of subject-matter specialists help to strengthen extension services and transfer technological innovations from the scientists to the farming communities.

Program Strategies

To avoid a wide and disparate scatter of unrelated projects across disciplines, commodities, and geographic regions, CAPS has chosen to concentrate its support in a few carefully selected topics and areas. The choice of focus is based on a detailed assessment of needs and opportunities accounting for such factors as national government priorities, regional or international significance of the research, possible environmental impacts, potential for a positive impact on small-scale producers and especially disadvantaged groups such as women and the landless, and the level of research resources provided by the governments concerned and other donor organizations.

Those topics that, although important, may be overlooked or neglected by other donors are frequently supported.

The choice of project subjects is also determined by the expertise of the program officers, who are primarily responsible within

CAPS for developing, monitoring, and providing technical-back up for the projects. All have a strong scientific background with experience in development research: they are based at the IDRC's regional offices throughout the world.

Systems Research

The introduction of new, high-yield cultivars of wheat and rice in the early 1960s led to dramatic increases in their production in many developing countries. This phenomenon, often referred to as the "Green Revolution," gave rise to a widespread optimism that similar "revolutions" could be achieved in most commodities. Since then, however, few other such widespread and dramatic increases in productivity have actually been achieved, in spite of the many efforts of national and international agricultural research institutions. The reasons for the success with wheat and rice and comparative failure with most other species has been studied and it became evident that the new wheat and rice technology was adopted mainly by farmers who had sufficient water, were able to provide the necessary inputs (especially fertilizer), and were in areas where the infrastructure for marketing and supply were adequate. Many small-scale farmers living in the tropics and subtropics do not have the advantages of such conditions.

Research has shown that small-scale farmers in developing countries are economically rational and are generally willing to adopt innovations they consider to be advantageous. Most live in highly unpredictable environments, where input and marketing infrastructures are often unreliable. They simply cannot afford to take risks. Recognizing this situation, the objectives of research must be defined by the explicit needs of farmers within the circumstances in which they live and work. All too often, research objectives are based on the preconceptions of scientists who have little appreciation of the real problems of small-scale farmers.

Systems research, which attempts to understand as fully as possible the living and working environment of a farming family, is proving to be effective. It is a holistic approach to research involving not only individual commodities or enterprises but also the interactions between them. It accounts for the opportunities and constraints of the social and economic, as well as physical, environment of the target farming communities.

The systems research supported by CAPS involves the farmer in all stages from diagnosing researchable problems, through designing and testing solutions, to validating and disseminating appropriate technologies. This invariably demands a multidisciplinary team approach, with much of the research carried out on farm, often under the direct management of farmers themselves.

In all research supported by CAPS, special attention is given to supporting research aimed at improving the stability and sustainability of production. This is especially the case in systems research

projects. Solutions to problems are sought that are safe both to the environment and to human health.

The CAPS program divides its support for systems research into three subprograms: cropping systems, animal production systems, and crop–animal systems and agroforestry.

Cropping Systems

Smallholders in developing countries have to ensure that they produce adequate food to feed their families as well as a surplus to sell for essential purchases. Shortage of land is a major constraint, especially in Asia and parts of Latin America. The productive potential of the land varies widely depending on soil type, topography, and climate. The weather, pests, and access to labour and credit are variables that often threaten survival, especially of the poorest farmers. Under these generally adverse conditions, farmers have developed traditional cropping patterns and practices and have selected crop varieties that are least vulnerable and best adapted. This process of trial and error is now too slow because so many other changes affect the production environment. Increased population growth has reduced farm size and led to the cultivation of less fertile land. The short-term expediency of removing tree cover for more frequent cropping has in turn caused the erosion of fragile soils.

Although, in recent years, emphasis in new cropping systems projects has shifted from Asia to Latin America and Africa, IDRC's most comprehensive experience has been in Asia. Since 1975, IDRC has provided funding through IRRI to the Asian Cropping (now Farming) Systems Network (ACSN) for workshops and training. Together with other donor agencies, research by five member countries of the network has also been supported directly. Most of the IDRC projects have completed their third phase, and each of the host countries has developed its own network for cropping systems research. In the Philippines, for example, more than 100 national research sites were established by 1984. ACSN has been particularly effective in developing the systems research methods that enable scientists to interact effectively with the target farming communities and ensure that farmers will cooperate and participate in the research. These methods include a sequence of steps from initial site description through design of alternative cropping patterns or other component technology, on-farm testing, preproduction evaluation, and pilot production to, finally, extension–production.

The effectiveness of cropping systems research has been demonstrated in many of the projects supported by CAPS. In Sri Lanka, for example, after 3 years of experimentation, a pilot production program was started in 10 villages; 3 years later, it had expanded to 603 tanks (reservoirs). Rice yields in one large site increased from 1290 to 5200 kg/ha per year.

In Central America and the Caribbean, research attention has focused both on annual crops such as maize, beans, roots, and vegetables and on perennial crops, especially bananas and plantains. Projects, such as those in Colombia, the Dominican Republic, Honduras, and Jamaica, have demonstrated the potential of systems research and contributed to strengthening the capacity of national programs to carry out such research.

In Africa, during the last decade, CAPS largely supported research on intercropping. This has helped to establish intercropping research in agronomy and crop-improvement programs throughout Africa. Unfortunately, relatively little technology from the projects has proven useful so far to farmers; probably because much of the development was confined to research stations. Most of the original intercropping projects have now evolved into cropping systems projects conducted on-farm and are soon expected to have a beneficial impact at the farm level.

In the next few years, CAPS will increase its support of national programs to expand their cropping systems research. This will encourage crop commodity teams to adopt a broader systems perspective and, where possible, will support multicommodity–multidisciplinary research teams. The forging of strong links between commodity researchers, extension workers, and farmers are key elements to sucess.

Animal Production Systems

Research in the Animal Production Systems subprogram is subdivided into three sectors: large and small ruminants and nonruminants.

Large Ruminants

Livestock are an integral component of small-scale farming systems in most developing countries. They are important as food and as a source of cash income. Livestock also provide draft power; skins, hides, and fibre; and manure, which serves as valuable fertilizer or fuel.

In Latin America, livestock are most important as a food source and are least used for power. The opposite is true in the Far East, where animals supply over 90% of the farm traction, but where only about 12% of the dietary protein is of animal origin. Throughout Africa, the Near East, and Latin America, livestock production relies heavily on natural pastures and up to 75% of the total land area may be used for grazing. Ruminants, in particular, can feed on land that is unsuitable for crop production. In the Far East, and wherever natural grazing lands are scarce, ruminants must rely on by-products, crop residues, or specially grown fodder.

CAPS gives priority to research on ruminants, specifically to cattle and to a lesser extent buffalo, because of both their large numbers in developing countries and their importance as sources

of milk and draft power. There are about 840 million head of cattle in the developing world compared with 125 million buffalo. In view of the general worldwide neglect of buffalo by researchers, CAPS is increasing its funding to these species.

A small amount of CAPS' support is also allocated to research on the South American camelids, the llama and alpaca. These species are well adapted to the harsh and erratic climate of the high-altitude areas of Bolivia, Chile, Ecuador, and Peru. Camelids are kept by Andean farmers for wool, meat, skin, and transport.

Most of the cattle-based projects funded by CAPS are in Latin America or eastern Africa. In Latin America, CAPS supports a network on animal production systems research, the Red de Investigación en Sistemas de Producción Animal de Latinoamerica (RISPAL, Latin American Animal Production Systems Network), with a full-time coordinator based in Costa Rica and direct support to about 10 national programs. The network is widely recognized as a world leader in research methodologies for animal-production systems. Training has been an important component of many network projects. In Costa Rica, for example, research has included theses for 17 masters' and 1 doctoral degrees. CAPS research on large ruminant production systems is expanding in eastern and southern Africa with on-going projects in Botswana, Burundi, Tanzania, and Zimbabwe. Eventually, a network similar to RISPAL may be established.

Small Ruminants

According to FAO figures, there are about 600 million sheep and 440 million goats in developing countries, representing 56 and 96% of the total world population of these two species respectively. They exceed cattle and buffalo in number in the developing world. Small ruminants, vital to many pastoral systems, thrive in areas that are unsuitable for cattle, for example, very dry regions and tsetse fly-infested areas. They are most important in Africa, the Middle East, and Asia.

The smaller size, shorter generation period, and higher prolificity of sheep and goats compared with large ruminants give small-scale farmers more management flexibility and greater opportunities to adjust to the fluctuating supply of feed.

In recognition of their importance, CAPS is expanding its support to the sheep and goat sector, projects have been started in Egypt, Mexico, Peru, the Philippines, and Swaziland, and others are planned for Africa and Asia. The research will study the extensive nomadic and transhumance systems in the Near East and South Asia, the use of natural pastures in Latin America, and the extensive and semi-intensive systems in Africa and those involving arable land and tree-cropping in Southeast Asia.

As with other CAPS animal-production systems research, the emphasis here is primarily on management and the provision of feed rather than on genetic improvement or basic health.

Nonruminants

Nonruminants are important in many smallholder systems and can even serve as food or a cash source for the landless. Although fewer resources are allocated by CAPS to this sector, much of the research has a large potential to benefit the very poorest sections of the community. Support can be broadly classified into three topics: pigs, "microlivestock," and bees.

CAPS currently funds only one project on pig farming, designed to improve production systems for native swine in El Salvador. The target farmers generally have very small herds (one or two sows) and frequently less than 1 ha of land. Results to date have shown that certain inexpensive improvements to what are essentially low-input, low-risk scavenging systems could increase productivity. Future CAPS support for pig research will be targeted at similar small-scale systems.

Traditional systems of raising "microlivestock" species such as rabbits, poultry, and guinea pigs require little or no land and only minimal capital resources. Many are raised in the city. Guinea pigs, for example, are widely reared in urban apartments in Peru, where about 70 million guinea pigs are consumed each year. The species is also an important source of meat for the poor throughout the highlands of Bolivia, Colombia, and Ecuador. CAPS recently initiated research projects on ducks in Indonesia, guinea pigs in Peru, and rabbits in Tanzania. In each case, these projects are expected to form the nucleus of small informal research networks in the respective regions.

Beekeeping is important to small-scale farmers and the landless. A project in Malaysia has achieved considerable success in developing and validating improved management practices at the farm-level, with better hive designs and more efficient methods of disease and pest control, for both the honey bee (*Apis melifera*) and the local species, *Apis cerana*. Other wild species, such as *Apis dorsata*, that are important in "honey-hunting" systems are also receiving attention. A CAPS-funded project in Colombia is studying the problem of Africanized bees, a particularly agressive strain that is spreading through the Americas. Although support for beekeeping will remain a minor activity of the Program, a network of small projects will be developed in eastern Africa and possibly in Southeast Asia in the next few years.

Crop–Animal Systems and Agroforestry

Crop–Animal Systems

Most farms in developing countries raise both crops and animals. Such mixed farms produce over 80% of the livestock in the tropics. Interdependence between crops and livestock is often crucial to the success of smallholder mixed-farming systems and whether they can be sustained.

Livestock consume crop residues, specially grown fodder, or feed and in return provide manure and power for the production of crops and the income from livestock may be used to purchase inputs for crop production. Equally, income from crop production may be used to purchase livestock.

A thorough understanding of such mixed systems can help to identify constraints and opportunities for increasing or stabilizing productivity, which might be missed in research concentrated on a single sector or commodity. CAPS places high priority on research aimed at understanding small-scale farming systems in an effort to develop appropriate improvements. The research generally requires an in-depth knowledge of the social and economic circumstances of the target farming families and seeks input from sociologists, anthropologists, and economists. Special attention is given to the particular needs and role of women in agriculture.

The number of crop–animal systems projects funded by CAPS has grown rapidly in recent years. Many of these have evolved from cropping systems research projects and from animal-production systems research. An excellent example is the establishment of the Asian Cropping Systems Network (ACSN).

In 1971, IDRC funded a multiple cropping project at IRRI in the Philippines. With continued support from IDRC and other donors, and the increased involvement of many national agricultural research programs in the region, the ACSN was established in 1975. Soon some notable successes were achieved and researchers

found that, in many areas, livestock could contribute up to 40% of total farm income in rice-based systems.

By 1982, the ACSN scientists were sufficiently confident in their methodologies and results to involve animal scientists in their projects. Data on the role of livestock in the farming systems were gathered in several countries and, in 1983, IDRC supported the first crop–livestock meeting of the ACSN. The name of the network was changed to the Asian Farming Systems Network (AFSN) and each of the five participating countries — Indonesia, Nepal, the Philippines, Thailand, and Sri Lanka — began to develop crop–livestock research projects. Although it is still too early to expect an impact from these new projects at the farm-level, progress on developing methodology has been encouraging.

One of the most advanced crop–animal systems research projects, started in Mali in Africa in 1977, has contributed significantly to developing indigenous research capacity through training and institution building. It also achieved success at the farm-level: in one village, farmers who received credit for the purchase of improved maize cultivars and fertilizer were able to raise yields to 4.3 t/ha. The village, originally a net importer of food, soon had a surplus for sale; several neighbouring villages recently asked to participate in the program. In another community, where animal feed was in short supply in the dry season, promising results have been achieved in on-farm trials with the addition of local rock phosphate to an introduced cultivar of forage cowpea.

Other farming systems projects supported by CAPS in West Africa include the establishment of the West African Farming Systems Research Network (WAFSRN). This network, through a coordinator and elected steering committee, encourages and strengthens farming systems research in the region.

A new sector of research support within the Crop–Animal Systems subprogram is integrated farming–aquaculture systems. Several projects have been started recently and more are expected over the next few years. Support in this sector is in collaboration with the Fisheries Program of AFNS. Current projects are aimed at rice–fish systems, where fish are raised in paddy fields. In addition to the direct benefits from raising fish, past research has shown that rice yields can be increased as a result of better water management, fertilizing effects, and possibly reduced diseases and pests. Other agriculture–aquaculture systems will be studied in future.

Agroforestry

Trees and shrubs are a valuable component of many farming systems and have the potential to make an even greater contribution in many parts of the world. They play a key role in improving the stability and sustainability of agricultural production, especially in more fragile environments. On land that is liable to erosion by water, well-rooted perennial species can help stabilize the soil and,

in areas exposed to strong winds, trees are often planted as windbreaks to protect crops and soils. In addition to this protective function, and depending on the particular species, trees and shrubs can also help maintain soil fertility by fixing nitrogen and recycling nutrients. They also provide a wide range of products such as food, animal feed, fuel, building material, mulch, and products for industrial processing.

Agroforestry, the integration of trees and shrubs within agricultural systems, is being given increased support by the CAPS Program. Past efforts have mainly involved research on alley farming in West Africa, although other topics are receiving increasing attention. In alley farming, crops are grown between rows of trees or shrubs, which are kept pruned, and the clippings are either fed to animals or used as a mulch. The system is particularly valuable in the more humid tropical areas where mulch has been shown to help protect the soils from erosion and stabilize the productivity of the crops grown between the hedgerows.

Past support for agroforestry within IDRC has come mainly from the Forestry Program, which, for example, played a leading role in the establishment of the International Council for Research in Agroforestry (ICRAF) based in Kenya. However, because the efforts of agriculturalists and foresters on this topic must be better integrated, CAPS support and expertise are also considered valuable and the technical and financial resources of the two programs are now being pooled to support research in this sector of common interest.

Component Research

Between 30 and 40% of the CAPS budget is spent on systems research. Although the remainder is allocated to research on component technologies, here too the emphasis is on applied and adaptive research involving the farmers themselves. Most projects include on-farm research as an integral part of their activities even in cases such as plant breeding where most experiments are carried out in research stations. This keeps the scientists in touch with the needs of the farmers and ensures the relevance of the research objectives and methods. At the same time, involving farmers and extension workers simplifies the first steps in the transfer of technology from researchers to the farming communities.

CAPS funds research on component technology in seven subprograms. Six concern a particular group of commodities, or factor of production, and the seventh aims to increase the overall efficiency and effectiveness of research through improving research management.

Annual Crops

Annual Crops is by far the largest of CAPS' subprograms, accounting for 25% of the total budget. Support is given mainly to important but neglected crops, especially cereals, grain legumes, oilseeds, and roots and tubers.

Cereals

Cereals are a major source of carbohydrates and protein in the diets of low-income people in developing countries. About half the cultivated land in the world is devoted to cereals, and wheat, rice, and maize — the three major cereals — account for almost 80% of total cereal production. Most of the world's rice comes from Asia, whereas maize is the predominant crop in Africa and South America. Wheat has greatest importance in temperate regions, during cool seasons in the subtropics, and at high elevation in the tropics.

National program planners as well as international donors recognize that production of these three crops must be increased to improve the nutritional levels of many, if not most, of the world's malnourished peoples. Wheat and rice cultivars that are higher yielding, disease resistant, responsive to improved conditions, and suited for more intensive cropping formed the basis of the Green Revolution. The International Agricultural Research Centres (IARCs) have played a major role in the development of this technology: the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT, International Centre for Maize and Wheat Improvement) for wheat and IRRI for rice.

CAPS has emphasized rice-based systems research over the development of component technology for rice per se. Research on maize and wheat have received only limited attention, mainly through IDRC's cooperative programs where the special interests and expertise on these crops within Canada are used to help provide solutions to the problems confronting developing countries. In this way, research has been supported on weevil resistance in maize, barley yellow dwarf virus, and fusarium head blight of wheat through projects involving specialists at Agriculture Canada and Laval University with researchers at CIMMYT and in Chile, China, and North Africa.

In view of the relatively large amounts of resources channeled into research on the three major cereals by national governments and other funding agencies, CAPS gives priority to research on other less-studied cereals that are, nonetheless, extremely important to a large number of the world's poor.

During the first 10 years of AFNS, considerable support was provided for sorghum research, largely against the background of the development of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Most of CAPS' recent support of sorghum research has gone to Africa where projects have been funded in Rwanda, Somalia, Uganda, and Zimbabwe. The results of several of these initiatives have been encouraging. In Uganda, for example, scientists at the Serere Station have successfully bred and released two new cultivars that are now being widely tested on farmers' fields in collaboration with other organizations in the

country. CAPS has also funded a series of workshops bringing together scientists from eastern Africa under the joint ICRISAT and Semi-Arid Food Grain Research and Development (SAFGRAD) program.

CAPS has also provided funds specifically to tackle the very serious threat to sorghum production posed by the parasitic plant witchweed (*Striga* spp.). This parasite also attacks such crops as maize, millet, and cowpeas. Projects in Burkina Faso and Sudan and at ICRISAT's headquarters are developing sorghum resistance to this pest. The Burkina Faso project in particular has made good progress with the development of several promising sorghum varieties. In the future, CAPS may provide some support for a network involving national programs, international centres, and institutions in developed countries.

In recent years, funds for sorghum research have increased substantially from other donors. CAPS support, therefore, is shifting to millet and other minor cereals.

In the past, most CAPS projects for millet research were based in Asia, although others in Uganda and Zimbabwe have had small components on millet. In India, some excellent cultivars of Italian (Setaria) millet have been developed at the Nandayal Centre and some promising Proso millet lines from Pune are under advanced testing. Good progress has also been made in Bangladesh, originally assisted by an adviser from the Mennonite Central Committee (MCC) of Canada. Both Proso and Setaria millets are important as short-duration crops in Bangladesh: the former being grown on the temporary islands left by the receding floods and the latter in temporarily dry areas. In Uganda, the millet research now concentrates mainly on finger millet especially after the identification there of male-sterility, which is proving useful in the breeding program.

In October 1986, IDRC cosponsored an international meeting at Bangalore, India, on minor millet species. As a result of this meeting, CAPS expects to increase its support for millet research in both Africa and Asia through several small interlinked projects.

In the past, CAPS was a large supporter of research on triticale, an artificial crop developed through crossing wheat with rye. Although direct funding for the development of new primary and secondary triticales has now ended, limited financing continues for evaluating improved germ plasm within cropping systems.

Grain Legumes

Legumes are broadly classified into two main groups: the grain legumes, which are grown mainly for the pods and seed, and the forage legumes, which are grown mainly as a whole-plant forage.

Legumes are often grown as a "break crop" in rotations to help prevent the build-up of certain pests, diseases, and weeds. They supply most, if not all, of their own nitrogen through their symbiotic association with *Rhizobium* bacteria. A significant

residue of usable nitrogen may remain in the soil for a subsequent crop in the rotation. Legumes are commonly grown in mixtures or intercropped with other species so that the companion crop may benefit from the fixed nitrogen. For these reasons, legumes are considered an important element in making agricultural production more sustainable.

Food legumes are a valuable source of protein especially when eaten with cereals, as is often the case in traditional diets, because the amino-acid profiles of food-legume and cereal proteins are complementary. The sale of food-legume seeds provides a cash income in many parts of the world, and the hulls and straw are often used as animal feed. If grain prices are controlled at a low level, the straw may even generate a higher income per unit area than the grain.

The two major ecological groups of pulses are warm season (summer) types — such as phaseolus bean, cowpea, pigeon pea, mung bean, groundnut, and soya bean — and cool season (winter) types, such as pea, chick pea, faba bean, lentil, and grasspea (lathyrus).

Although overall legume production has grown modestly, 0.4% per year from 1970 to 1980, areas under production have decreased noticeably for some specific legumes, especially in Africa and parts of West Asia. Several factors, such as higher labour costs, lack of appropriate mechanization, and low prices, have contributed to this decline.

When IDRC began funding food-legume research in the early 1970s, there was little other support from other donors. However, the growing recognition of the role of food legumes and of the need to increase agricultural diversity have resulted in increased support for food-legume research worldwide. Although few national programs had well-developed research on legumes in the early 1970s, many have today: the IARCs — especially the Centro Internacional de Agricultura Tropical (CIAT, International Centre for Tropical Agriculture), the International Institute of Tropical Agriculture (IITA), ICARDA, and ICRISAT — have been particularly active in fostering this increased interest and research capability.

Grain legumes have received more support from CAPS than any other commodity with an allocation of over 1 million CAD/year in each of the last 5 years. CAPS continues to recognize the importance of grain legumes and to provide funding especially to the weaker national programs; however, the proportion of the total budget allocated to these crops will decrease over the next few years because greater donor support is now available.

Several projects on cowpeas have been supported in West Africa, linked to the program at IITA. These have included projects in Burkina Faso, Mali, Niger, and Sierra Leone. The research in Burkina Faso, for example, has led to the development of a high-yielding photoinsensitive cultivar with broad adaptation and good resistance to *Striga*. This cultivar is now being tested widely and is

being adopted successfully by farmers in several countries of West Africa.

In Southeast Asia, research has been funded in association with the ACSN for food legumes that fit into rice-based cropping systems. Good progress has been made especially with soya bean in Indonesia, mungbean in the Philippines, and groundnut in Thailand.

Substantial progress has also been achieved in several projects in the Middle East linked to ICARDA in Syria. IDRC played a major role as implementing agency in the establishment of ICARDA and has continued to provide funding both to its program and to several national ones in the region. The research encompasses three main cool-season legumes, chick pea, lentil, and faba bean, grown in a wide range of environments. In Pakistan, for example, good progress has been made in identifying and testing a cultivar of chick pea with resistance to ascochyta blight, a disease that can devastate the crop. A large area is now covered by resistant cultivars and, if the resistant cultivars can be made more tolerant of cold, they could be planted much earlier than conventional varieties through much of the Middle East. Such earlier planting, which does not compete with other crops for land, can increase yields substantially. Cultivars and practices for earlier planting are now being widely evaluated with IDRC support in several countries of the region including Algeria, Jordan, Morocco, Syria, Tunisia, and Turkey.

CAPS' continuing support for legumes will also include those crops that are not covered by IARCs, notably peas and lathyrus. Lathyrus, in particular, has recently received greater attention. It is the most widely grown grain legume in Bangladesh and is common in parts of northern Afghanistan, Ethiopia, India, Nepal, and Pakistan. It is extremely drought resistant, but, if eaten in excess as is common in drought years, it can cause paralysis because of a neurotoxin in the seed. The disease, called lathyrism, is particularly prevalent among the poor who are unable to afford other foods. Varieties that are very low in the neurotoxin have been identified and CAPS is expanding its support to develop and test them further in national programs. The PPS Program in AFNS as well as the Social Sciences and Health Sciences divisions of IDRC are also interested in supporting research on lathyrism.

Annual Oilseeds

Oilseeds are in short supply in much of the developing world. Vegetable oil is an essential component of the diet and countries such as India and Pakistan spend large amounts of foreign exchange to import it.

Cotton and groundnuts, the major annual oilseeds of the semi-arid tropics, have received much international research support in the past, as have soya beans in the more humid and irrigated areas. Other oilseeds such as sesame, safflower, sunflower, rapeseed,

mustard, niger, and linseed, which are also widespread and important for subsistence farmers, have received much less attention and offer a largely undeveloped potential. No international research centre directs research on these crops and existing associations, such as those on the brassicas and sunflower, are aimed mainly at the developed world.

CAPS has supported several research projects on the lesser known annual oilseed crops, mainly within South Asia and Eastern Africa, in particular, sesame, safflower, niger, and rapeseed and mustard. However, other annual oilseeds supported by CAPS include sunflower, linseed, and to a limited extent castor.

Sesame is an ancient crop with an oil of excellent nutritional quality. Under prevailing conditions of cultivation, yields are low and pest and disease problems are serious. Because the sesame capsules shatter as soon as they are ripe, causing high seed losses at harvesting, mechanization is limited. Through research on sesame in Tamil Nadu, India, which has received CAPS support since 1978, a wide range of germ plasm has been assembled and many crosses made. Promising cultivars, now in advanced adaptive trials with farmers, have shown yield increases of 20–30% over the recommended cultivar. In Egypt, varieties outyielding the commercially available type by more than 50% have been identified. Promising sesame lines have also been selected in Ethiopia and Sri Lanka.

Research on safflower has been confined mainly to Ethiopia and Indore in India. The development of high-yielding spineless types is making good progress in India and is expected to permit this extremely drought-resistant crop to be introducted into new areas. Safflower grows well on residual moisture, because of its well-developed root system, and has a good potential in many rainfed regions of the world, especially in parts of Africa. The linking of researchers in India and Africa and the exchange of germ plasm could make a valuable contribution to safflower improvement in both regions.

Niger, similarly, is a crop that could benefit substantially from the exchange of germ plasm between Africa and India. Niger, or noug as it is called in Ethiopia, is a subsistence crop that is well adapted to heavy, poorly drained soils. It appears to be a good "cleaning" crop, suppressing weeds both in the current and subsequent crop in the rotation. Research on niger in Ethiopia is progressing well and some promising cultivars have been identified.

Rapeseed and mustard (*Brassica* spp.) are cool-season or high-altitude crops in the tropics. IDRC has supported research on these crops in China, Egypt, Ethiopia, and India and has been able to draw upon the considerable Canadian expertise in this field. Excellent progress has been made in several projects, for example, in developing early cultivars of rapeseed in Pantnagar, India, and in improving quality characteristics of both the oil (low erucic acid

levels) and oilcake (low glucosinalate levels). Improved brassica varieties are now estimated to cover about 80 000 ha of land in China.

IDRC has supported the development of a network for scientists researching annual oilseed crops in South Asia and eastern and southern Africa. The network has its headquarters in Ethiopia and is hosted by the Ethiopian Institute of Agricultural Research. It has a full-time coordinator and produces a newsletter, holds annual workshops, and organizes training. This network has successfully brought together scientists from the two regions to share experience, ideas, and materials. Considerable thought is now going into the further development and strengthening of this network to ensure that it continues to provide adequate mechanisms to meet the needs of the participants.

Roots and Tubers

CAPS has funded many projects on tropical root crops including sweet potato, yam, cocoyam, and solanum potato. By far the largest portion of the funding, however, has been allocated for research on cassava. This major root crop has enormous yield potential, which in terms of energy production is higher than almost any other crop. Total world production exceeds 110 million t/year (fresh roots) and the crop is grown in more than 80 countries. About 70% of the world production comes from only five countries — Brazil, Indonesia, Nigeria, Thailand, and Zaire.

During the past decade, the crop has become increasingly important as animal feed and it is also used to a great extent in the manufacture of industrial starch. Over 15 million t of fresh root equivalent are traded internationally in dried form each year. Cassava grows well under semi-arid conditions, is a stand-by against crop failure, and is easy to grow. Mosaic and bacterial blight are troublesome diseases and green mite and mealybug can be serious pests.

Sweet potato is adapted to higher rainfall areas and can also be very productive. However, losses from virus diseases and damage from potato weevil may be serious. Both cassava and sweet potato can be stored well in chipped or sliced form after drying. A wide range of other root crops such as cocoyam and yam grow in almost every garden plot throughout the higher rainfall zones of the tropics. These, so far, have been largely ignored by researchers.

The crop that has received greatest research attention worldwide, however, is the solanum or Irish potato. This crop does not tolerate heat but grows well in the cool seasons, and at high elevations, in the tropics and subtropics.

IDRC's support for research on root crops began with cassava in Latin America in 1971, with funding going initially to CIAT in Colombia and to national programs in Brazil, Ecuador, and Peru and the Caribbean. As these programs strengthened, and funding has

generally been taken over by the national governments, CAPS shifted its focus toward research in Africa and, to a lesser extent, Asia.

In Africa, most of the research on roots and tubers has been linked to IITA in Nigeria. In West Africa, national programs in Cameroon, Congo, Liberia, and Nigeria have all received CAPS support and results have been encouraging. In Cameroon, for example, some good cassava clones have been identified that offer both mosaic resistance and high yield. Improved cultivars of cassava and sweet potato are now being disseminated to farmers and planting materials of yam have been multiplied for distribution.

CAPS also funds root and tuber research in eastern Africa in Rwanda, Tanzania (Zanzibar), and Uganda. The Rwanda project served as the base in developing a root-crops research network for the region, although the headquarters has now been moved to Malawi. Although CAPS remains a major donor, this network, coordinated by IITA, is also supported by other donor agencies.

The research in Zanzibar, which has been funded for several years, has been successful in identifying resistance to green spider mite in cassava. This material is now being tested in other African countries that have been infested with cassava mite since its accidental introduction into Uganda in 1970.

In Asia, CAPS has supported root crops research in India, Indonesia, Malaysia, the Philippines, Sri Lanka, and Thailand. Many

of these projects have now been taken over by the national governments, although CAPS continues to fund root-crop research in the region.

CAPS gives a lower priority to research on the solanum potato because this crop is generally well supported by other donors and national governments. A project funded through CIP has provided support for a successful research network on potato for the Andean region, PRACIPA. This project serves five countries, each of which carries out an agreed program of research, contributing knowledge and germ plasm for the benefit of all the participants. The network, in which the participants agree to adjust their own objectives and activities, ensures complementarity and thus increases overall research efficiency. It is a model that is being tried in other regions and with other commodities.

Other Crops

The Other Crops subprogram has two main sectors: Andean crops and horticultural crops.

The Andes have a wealth of species that are rarely found outside the region. As a result, research has been generally inadequate and many species are now being replaced by others having a higher yield potential or more ready local and international markets. The erosion of local genetic resources of many of the Andean species is serious and further efforts are urgently required if they are to be saved.

CAPS has supported research on Adean crops for several years in Bolivia, Ecuador, and Peru. A small, informal network of researchers interested in Andean crops has been established and this has generated a good interchange of ideas, results, and genetic materials. CAPS is now exploring possibilities for linking these scientists with their counterparts working in mountain systems elsewhere in the world, especially the Himalayas.

Among the Andean crops that have received attention are: quinoa, *kaniwa*, oca, and ullucu. Quinoa (*Chenopodium quinoa*) is important up to altitudes of 4000 m and with 200–800 mm of rain and is often grown in rotation with potato and barley in areas unsuited for maize. Although yields are low, the protein content is about 14%. *Kaniwa* (*Chenopodium pallidicaule*) is similar to quinoa but is more tolerant of frost and diseases and has a higher protein content. Oca (*Oxalis tuberosa*), the most important root crop in the Andes after potato, has an 8- to 10-month growing cycle and is adapted to a range of difficult Andean conditions. Ullucu or melloca (*Ullucus tuberosus*) is another widely grown root crop with good frost resistance but it has lower yield potential than oca.

A national Andean research program has been established in Peru, in part at least as a result of the IDRC-supported project. The other governments concerned are increasing their resource allocation for research on Andean crops and cropping systems. CAPS,

therefore, expects to gradually reduce its own funding for these crops over the next few years.

Currently, CAPS supports only two projects on vegetables, both in Asia. From a global perspective, however, vegetables account for over 7.6% of the total value of all foods, ranking fourth after cereals, livestock, and roots and tubers. They are important in all areas of the world as a source of vitamins, minerals, and fibre, and are essential for amino-acid balance. Although vegetables provide an important source of cash income for many smallholders with good access to urban markets, most subsistence farmers grow them in home gardens for their own consumption.

As urbanization increases, the demand for vegetables is expected to rise and their importance is likely to expand in many developing countries. The need for increased research on vegetables is now recognized by many national governments and donor agencies and several studies are now under way to explore alternative methods for research support. CAPS is planning to increase the proportion of its budget allocated to research on vegetables and, in particular, on home gardening. However, priorities in terms of commodities, systems, and regions are still undefined and await the outcome of these studies and CAPS' own consideration of the various opportunities and issues involved.

Perennial Crops

Perennial crops, and farming systems based on them, are very common in the humid and subhumid tropics. They are not only important to large plantations and estates but are also vital to the livelihood of millions of small-scale farmers in developing countries. There are three main cropping types: perennial field crops, shrub crops, and tree crops.

Perennial field crops, such as sugarcane, pineapple, sisal, and bananas do not have the typical woody characteristics of trees and shrubs and generally require a considerable degree of cultivation.

Shrub crops, such as coffee and tea, have a vegetative cycle that is longer than that of perennial field crops and they may need a high labour input.

Tree crops, such as cocoa, rubber, coconut, and oil palm, may have a growth cycle lasting several decades and generally have a lower labour requirement.

To date, CAPS support has gone almost exclusively to bananas and plantains and, to a smaller extent, coffee. CAPS support for perennial crops is currently under review. Depending on the outcome, funding will probably be extended to a few other perennial species and systems that are important in smallholder agriculture and that currently receive inadequate research backing. The increasing importance attached to perennial crops by CAPS reflects their value for generating income and employment, their ability to

help prevent soil erosion, and their potential for stabilizing production and making it more sustainable.

The high priority given by CAPS to bananas (the term is used here to cover all *Musa* species whether eaten raw or cooked) is based on their importance in the diets of millions of the world's poorest people, living in humid and subhumid tropical regions.

Current world production of bananas is estimated to be over 62 million t. However, because the world export trade is only about 7 million t, the crop is clearly far more important globally as a food for local consumption that for export. Bananas are an important staple in the diet in many African countries where per-capita consumption may average more than 0.5 kg/day, generating 300–600 calories.

Dessert bananas for export are largely the domain of multinational companies, although not always. In the Windward Islands, for example, there are about 30 000 ha of bananas and over 70% of the growers produce less than 5 t of bananas each. Depending on the particular island, between 87 and 95% of all banana-producing farms are under 10 ha. CAPS-supported research in these islands has resulted in identifying and distributing a shorter cultivar that is resistant to wind and developing of several economic banana intercrops such as dasheen, peanuts, and cowpeas.

Recently, a form of leaf spot named black sigatoka has appeared and is causing severe damage to plantains and bananas in Asia, Central America, and elsewhere. It can be kept under control by frequent applications of fungicide, but this is not practical for small-scale growers. In Central America, for example, it is estimated that control of black sigatoka costs commercial plantations more than 100 million CAD/year.

Other serious threats to banana production include Panama disease, bunchy top, and burrowing nematode. Breeding for resistance to these diseases and pests seems to be the only adequate solution for smallholders.

CAPS has supported research on bananas in several parts of the world, including Cameroon, Costa Rica, Honduras, Jamaica, the Philippines, and the Windward Islands. In view of the lack of an international research institute with primary responsibility for bananas and plantains, several donors have joined under the leadership of IDRC to establish the International Network for the Improvement of Banana and Plantain (INIBAP). This network, with headquarters in France, aims to strengthen national and regional research programs and is developing subnetworks to serve the separate needs of Latin America, West Africa, East Africa, and Asia.

The other perennial species that has received limited support from CAPS is coffee. This crop provides an extremely important source of income for millions of small-scale producers in Africa, Asia, and Latin America. In most producing countries, coffee, grown predominantly by smallholders, is a major export commodity.

It can be grown on steep slopes and helps prevent soil erosion. It is ideal as a crop for isolated places as it is relatively easy to store and transport.

In Mexico, CAPS supports a project with the Commonwealth Institute of Biological Control (CIBC) on the biological control of coffee-berry borer. Parasites of the borer are being introduced from Africa for testing and eventual release in Mexico. A cooperative project between the universities of Costa Rica and Alberta is also producing interesting results in its research on the control of leaf spot disease.

It is expected that CAPS will continue to provide limited and focused support for research on coffee in the future.

Integrated Pest Management

In many parts of the world, agriculture is depending increasingly on agrochemicals to control crop pests and diseases — this poses increasing hazards to the environment and to human health. Strong evidence is emerging to link rising human mortality rates with increased pesticide use in developing countries. It has also been shown, in several instances, that pesticides often provide only a short-term solution because the pests develop new races that are resistant to the chemicals. The indiscriminate pesticide use also frequently reduces the numbers of natural predators dramatically and this can result in more severe pest problems than if no chemicals had been used at all.

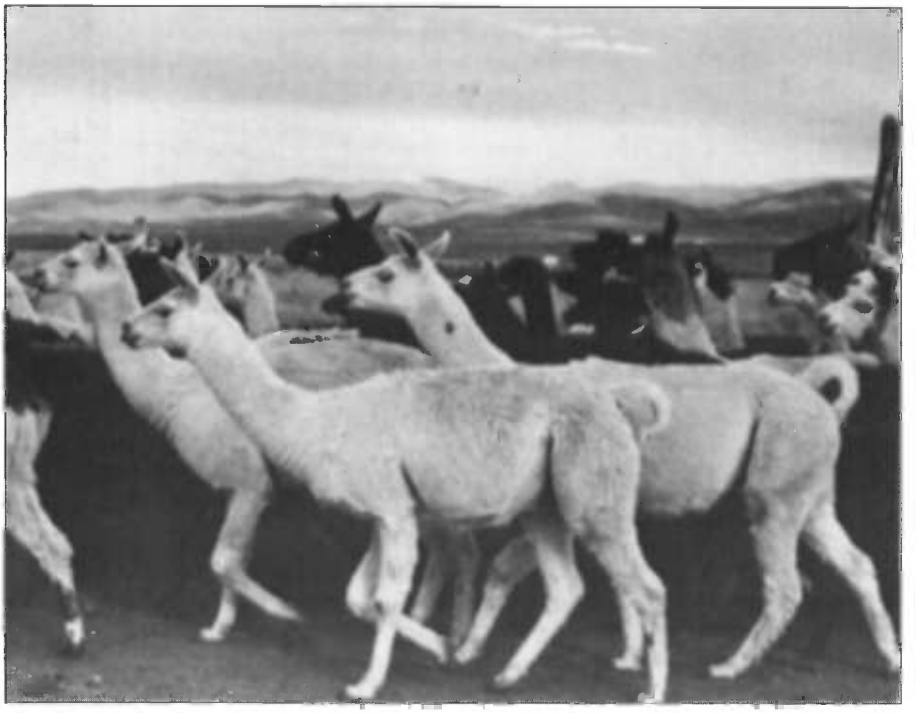
The problems associated with pesticide use are especially serious in developing countries where, frequently, spray equipment is incorrectly used or poorly maintained and labels may be absent or in the wrong language. In addition, farmers are often illiterate and may not understand that the correct spray rates, timing, and methods of application must be adhered to strictly and that reentry into a field after spraying must be delayed. Further, regulatory policies and methods of ensuring adherence to such policies are often inadequate. In many developing countries, farmers can freely obtain and use agrochemicals that have been banned or are heavily regulated in most developed countries.

In addition to the environmental and health hazards posed by the misuse of pesticides, their cost is a considerable burden to many small-scale farmers. In view of these problems, yet recognizing the immense loss of production and stability due to pests and diseases, CAPS gives special attention to supporting research on integrated pest management to provide effective, economic, and safe methods of control. Many of the projects on genetic improvement of crops aim, as a primary objective, at developing pest- and disease-resistant cultivars. The Program encourages pest-management regimes based on the use of such cultivars coupled with appropriate cultural practices and, only when absolutely necessary, the judicious use of agrochemicals.

Special attention, however, is also given to research aimed at developing biological controls for pests and diseases, and this is an area receiving increased support from CAPS. Current projects include

- The control of cassava mealybug and cassava mites in East Africa, linked to the very successful Africa-wide Biological Control Programme coordinated by IITA;
- The control of locusts in India through the use of protozoans of the genus *Nosema*;
- The use of bacteria (*Bacillus thuringiensis*) to control lepidopterous pests in Egypt and Nicaragua;
- The use of predatory insects (*Trichogramma* spp.) to control corn and sugarcane borers in China;
- The control of aphids in China through the use of predatory mites (*Aphidoletes* sp.);
- The use of parasitoids (*Prorops* sp.) to control coffee-berry borers in Mexico; and
- The biological control of psyllids on *Leucaena* in Southeast Asia.

In addition to these projects, several more are under discussion and other aspects of pest management, such as developing pest-monitoring services and using naturally occurring botanical pesticides, are also being investigated.



Animal Feeding Systems

The shortage of animal feed is recognized as the major factor limiting animal productivity in developing countries. CAPS supports research in two main sectors: pasture and forage improvement and by-product utilization.

Pasture and Forage Improvement

Pastures and forages constitute the most abundant and cheapest source of feed for grazing animals. About 25% of the total land area in developing countries is under permanent pasture. Pastures allow large areas of land of low productive potential to be used and they help to conserve and improve soil fertility. Animal production and productivity under grazing are generally low in tropical areas, a situation often associated with the pattern of availability and quality of pastures and forages throughout the year. Improvements can be achieved by better management and introduction of improved grasses and legumes, and even shrubs and trees in certain cases.

Pasture research for grazing conditions is slow and expensive and, although research institutions in many developing countries have allocated a reasonable part of their budget to such research, their output is adopted slowly by small-scale farmers. This lack of impact is caused by insufficient funds or lack of experience, or both, for conducting relevant research, inappropriate research methods, and the lack of adapted germ plasm and other appropriate new technologies.

An analysis of published literature has shown that only about 11% of pasture research trials involved animals in the evaluation; for Latin America, this value was only 1.3%. Only a very small proportion involved cattle, which constitute the major class of livestock in the developing world. The CAPS subprogram thus gives special emphasis to the development of inexpensive research methods for evaluating forages and pastures using the target livestock species.

Because small-scale farmers have limited resources, CAPS has given priority to developing low-input technologies, particularly the use of legumes, shrubs, and trees that can fix nitrogen, alone or in combination with grasses. Improving the present resource base (native pastures or rangeland) is also a priority. The choice of grasses, legumes, shrubs, or trees depends on the animal-production system practiced in the specific target ecosystem. In the grazing areas of Latin America and Africa, improving grasses and introducing pasture legumes is of highest priority, whereas in the humid areas of Asia where land is the main constraint, the emphasis is on using high-yielding grasses and legumes for cut-and-carry management and using trees and shrubs as forage.

CAPS supports research to improve pasture- and forage-based animal-production systems at national, regional, and international centres. It also encourages and funds the formation of research networks to promote exchange of information and germ plasm, and development and standardization of appropriate research methods.

Most support in the past has been given to projects in Latin America, where pasture-based systems are particularly important. More recently, support has been increasing to Africa and, to a smaller extent, to Asia and the Middle East.

In Latin America and the Caribbean, CAPS has supported the CIAT-coordinated Tropical Pastures Network since 1982. Through this link, projects in 17 countries of the region are developing standardized methods to evaluate pastures systematically. Germ plasm screened at CIAT and national centres is evaluated elsewhere in the region. Intensive short-term training has also been provided and information is exchanged regularly through meetings and CIAT's information service. More recently, the network has begun to help strengthen production systems for forage and pasture seed to ensure that adequate quantities of seed are available for testing, and to help develop commercial or government schemes for seed production and distribution.

CAPS support for the forage program at the Universidad Católica de Chile has resulted in the identification of eight highly productive species out of more than 500 accessions of grasses and legumes tested. Two late-flowering varieties of ryegrass were selected for their higher nutritive value and good association with clover. Many tonnes of seed of these varieties have now been sold to farmers in the Osorno region.

In another project at the Universidad Agraria la Molina in Peru,

a ryegrass–clover association has been developed that yields 18 t of dry matter (DM) at 15.2% crude protein (CP) under irrigation compared with a yield of 1.5 t DM/ha at 5.7% CP from the rain-fed native pastures. This has served as the basis of sheep-fattening production modules that allow stocking rates of 25 head/ha with gains of 200 g/day compared with 1 animal/ha and 100 g/day on rain-fed native pastures.

In Africa, a series of workshops supported by IDRC led to the creation of the Pastures Network for Eastern and Southern Africa (PANESA) with the main objectives of facilitating the exchange of information and germ plasm, training, and technical back-up. IDRC is providing funds for several of the national programs involved in the network, as well as supporting a coordinator located at ILCA.

CAPS is also providing funds to help develop a microbiology unit at ILCA so that it can undertake relevant research and training on *Rhizobia* and nitrogen fixation in tropical and subtropical pastures. CAPS funding for forage and pasture research in Africa is expected to increase over the next few years.

By-Product Utilization

Agricultural by-products are important feeds in many animal-production systems in developing countries. With the decline and degradation of grazing lands through overgrazing and the expansion of arable cropping, they have become increasingly important. The use of farm-produced by-products as animal feed is an efficient and ecologically sound use of farm resources.

The availability and use of crop residues vary considerably among the developing regions. Quantitative data on available agroindustrial by-products are limited, but many crop residues can be estimated from the land area under the crop, average crop yields, and appropriate crop-residue conversion ratios. On this basis, it is estimated that the amounts of crop residues available globally in 1981 were (in million metric tonnes): maize, 1000; rice, 500; pulses, 500; wheat, 500; oil crops, 300; sorghum, 300; barley, 200; sugarcane, 200; fruits and vegetables, 190; millets, 130; and oats and rye, 110.

The importance of the various by-products differs with the region: rice straw is most important in Asia and maize stover in Africa. Pulse crop residues may be small compared with cereals, but they contain larger concentrations of proteins than most other residues and are thus very valuable nutritionally. In the more extensive semi-arid regions, plants may often die before maturing and crop residues are thus often of good nutritional quality and able to sustain livestock above maintenance levels.

In addition to crop residues, various agroindustrial by-products such as molasses, oil meals, and brans are used as animal feeds. These are generally high in energy or protein (or both), and their use as feed can help to increase livestock productivity, especially

in intensive and semi-intensive production systems. Developing countries, however, are net exporters of these by-products.

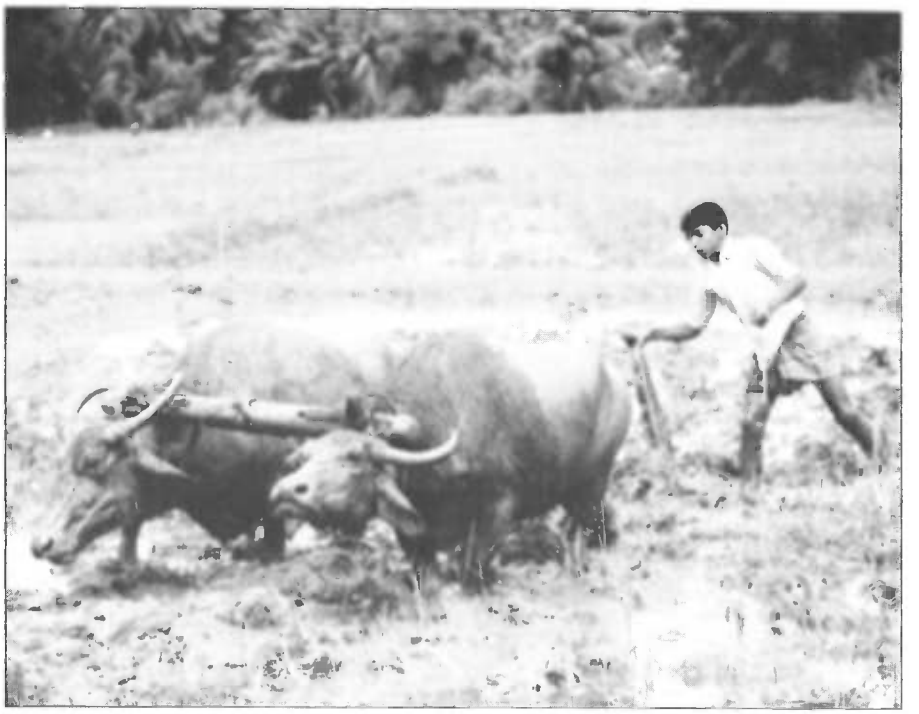
On a global basis, crop residues and other by-products are believed to account for about 25% of all ruminant feed. Surveys indicated that, in Africa, 70% of ruminants depend on crops residues for dry-season feeding. As crop and crop–livestock production systems intensify, grazing lands decline and crop residues increase in importance as livestock feed. This trend is not without problems, however. Limiting factors include difficulties in supply and storage, poor feed intake, low digestibility, low nutrient content, and antimetabolites or even toxic factors in the feeds. Poor animal performance can result from the use of a high proportion of certain crop residues and by-products. Significant progress has been made in recent years, however, in developing methods to improve the storage, quality, and intake of these residues.

Straws and other by-products have a wide range of competing uses: straw compost increases the organic-matter content of the soil and adds nutrients. About 50% of the commercial fertilizer currently used in developing countries could be replaced by composted straws. However, labour requirements for making and spreading compost are a major constraint. By-products are also used for fuel by direct burning. The technology is now available to convert straw into combustible gases that may become competitive with natural hydrocarbons in specific situations. However, the capacity to use these and other alternatives is usually small and they generally do not compete seriously with the use of by-products for animal feed.

The first two projects supported by CAPS on by-products were in Latin America and later three projects were undertaken in Asia. All others have been funded in Africa and the Middle East, and include projects in Cameroon, Cyprus, Egypt, Kenya, Nigeria, Sudan, and Tanzania.

In 1981, ILCA established the African Research Network for Agricultural By-products (ARNAB). A series of workshops, partly funded by IDRC, in various African countries stressed the need for extra financial support for ARNAB. In 1984, IDRC provided a grant to ILCA to coordinate the network. ARNAB aims to support and strengthen national research on the use of crop residues and agroindustrial by-products through collaborative research and information exchange in Africa. A major aim of ARNAB is to develop standard evaluation methodologies, standard terminology for accurately describing by-product feed, and on-farm study methods.

Africa will remain the major focus of research on by-product use, although some additional activities may also be supported in the Middle East and Asia. The use of residues from plantations for small ruminant production systems in Asia is one area that has been neglected and yet shows considerable potential. Support for this and other such opportunities will be provided when possible.



Animal Systems Component Research

Although the main focus of support for animal science research is on improving animal production systems, primarily through improved feeding and management, other components of the systems also receive limited attention. Three sectors, in particular, are targeted by CAPS for support: animal breeding, animal health, and draft-animal power.

Animal Breeding

As feeding, health, and other components of production systems are improved, so the genetic potential of local breeds can become a limiting constraint. Thus, improving this potential can lead to a more efficient and effective use of the improved production environment. Improvement of the genetic base of livestock in developing countries has been widely studied with varied results. For example, introducing purebred European breeds to the lowland tropics has been attempted frequently, but these attempts have generally failed, often at a large cost. In contrast, the carefully planned introduction of crossbred animals into the production system can usefully increase productivity.

CAPS rarely supports research on animal breeding per se, partly because of its long-term nature, but it does support the introduction of genetically improved animals into production systems when this is based on past breeding experience. For CAPS to support research on this topic, the methodology for quantifying the environment and animal characteristics must be clearly defined,

the research should be done in environments that allow the genetic potential of the stock to be adequately expressed, and there must be a practical and potentially viable system to multiply and distribute the improved animals to small-scale farmers rapidly.

Several successful projects that meet these criteria are currently being funded by CAPS. For example, local sheep breeds in Egypt are being improved by introducing and testing on small-scale farms of genetically improved animals that have 1/4-Finn or 1/4-Romanov bloodlines. In both Botswana and Burundi, researchers are trying to upgrade local cattle, at the same time as improving other components of the production systems, by introducing exotic bloodlines into the local breeds.

Animal Health

Losses caused by ill health in livestock can be dramatic. For example, about 10 million km^2 of Africa are unsuitable for cattle production because tse-tse fly-transmitted trypanosomiasis is present; in Bangladesh, about 45% of buffalo calves die during the first 6 months of life; and, in East Africa, up to 30% of calves die of East Coast Fever before they reach 1 year of age. In addition, nonfatal ill health because of chronic infectious diseases and parasites causes suboptimal growth, milk production, reproduction, feed conversion, and draft capacity.

CAPS has, so far, funded little research on animal health itself and prefers to leave the development of drugs, vaccines, etc. to the commercial sector or large institutions such as the International Laboratory for Research on Animal Diseases (ILRAD). However, animal health already receives some attention as a component of production systems and support on this topic will expand slightly. Special attention will be given to developing and evaluating low-cost programs that are likely to benefit, and be adopted by, small-scale farmers.

Draft-Animal Power

Draft animals represent a significant part of both total and liquid assets on many small farms. They play a major role in crop production and transport, especially in Asia and parts of Latin America, and they could potentially play a much larger role in parts of Africa. However, their precise socioeconomic role on small farms or the probable effects of replacing them by machine or human power is poorly understood.

Previous research on draft animals has tended to focus on implements and harness, and the animal factors have been inadequately addressed.

CAPS currently supports three research projects on the role of draft buffalo in local farming systems: in India, the Philippines, and Thailand. These projects attempt to answer the following questions: under what conditions is lack of power a constraint on small farms and with what consequences, how far are farmers prepared

to go in terms of extra time and money to increase their access to draft power, and what are the main constraints faced by farmers who wish to increase the input of animal power on their farms?

Based on studies such as these, it is expected that future research will be able to address specific, identified constraints and thus contribute to increasing the availability and effectiveness of draft animals on small farms.

Soil and Water Management

The Soil and Water Management subprogram is concerned with the rational exploitation and conservation of the major resources of world agriculture, particularly land and water.

In 1980, only about 40% of the total potential arable land in developing countries was under cultivation. However, this varied considerably from region to region — from 79% in the Far East and 63% in the Near East to 30% in Africa and only 25% in Latin America — and from country to country within regions. The increase in cultivated areas can be expected to contribute significantly to increasing food production over the next decades in Latin America and Africa but far less so in the Middle East and Asia.

Although an increase in area of arable lands will contribute substantially, it will solve only part of the problem of increasing agricultural production: probably only about 25% of the expected increase in food production over the next two decades. Under the most optimistic forecasts of the Food and Agriculture Organization (FAO) of the United Nations, the arable area is expected to grow at a rate of only 0.9% per year in the developing world, ranging from 0.1% per year in the most "land-hungry" countries to about 2% in those with plentiful land. Expansion of arable area does not come without risk. Many potential new arable areas are in extremely fragile environments. The soils may be easily destroyed or lost as a result of erosion. The larger effects on climate from the removal of natural vegetation such as rain forests must also be considered.

Throughout Africa, the breakdown of the traditional shifting cultivation and nomadic herding systems with expanding human and livestock numbers is leading to increased soil deterioration by erosion, leaching, and water runoff. This is an important contributing factor to the decline in per-capita food production and the stagnant economies in several African countries. Similar problems also occur in many other parts of the world.

The combination of land shortage and the danger of land degradation make it imperative that adequate measures are adopted to conserve and enhance the productive potential of the soil. At the same time, productivity must be increased substantially in existing cultivated areas.

CAPS currently supports research on soil conservation only in Kenya and Nepal, but this sector will receive considerably more attention in all regions in future.

After land, water is probably the most important input for agriculture. However, water resources will become increasingly scarce and they must be used more efficiently in both rain-fed and irrigated areas. Currently, about 105 million ha are irrigated throughout the world and it is expected that, by the end of the century, this area will increase by 40%. Irrigated land will then, however, only account for 16% of the total arable land.

Although much research has been done on large-scale irrigation systems, such as those in Egypt and Sudan, much less has been done on systems suitable for small-scale farmers in which individual producers, or small groups of farmers, pump their own water from a bore-hole or river. Such systems are potentially of great value, especially in drought-prone areas where even a single "life-saving" irrigation can make the difference between a harvest and complete crop failure. Although many irrigation problems can be solved technically, the effectiveness of many irrigation schemes is limited because of inadequate investment, lack of training, or poor management. CAPS will increase its support of research on small-scale irrigation systems over the next few years, with special attention to supplementary irrigation in Africa and the Middle East.

The use of fertilizers is probably one of the single most effective ways of increasing crop productivity. From 1965 to 1976, fertilizers were responsible for about 55% of the increase in yields in developing countries where their use has been growing more than twice as fast as in developed countries. This increase has been largest in Africa and the Far East. However, the amount used in developing countries is still relatively low, averaging 24 kg of plant nutrients per hectare in 1980 in developing countries compared with 115 kg/ha in developed countries in 1978. The variation in use is very large: from 3.6 kg/ha on low-rainfall areas to 100 kg/ha on fully irrigated land.

One major barrier to the increased use of fertilizer in developing countries is the foreign-exchange requirement and the high cost to farmers. The developing countries produced about 17.5% of the total world output of fertilizer in 1978/79, accounting for about two-thirds of their requirements. Many countries have the potential to achieve self-sufficiency in fertilizers, and research on the use of indigenous fertilizer sources (especially phosphate) is proving to be of special significance. The use of organic fertilizers is also expected to increase, and research on this topic, including the combined use of organic and inorganic fertilizers, will receive greater priority by CAPS in future.

Most of the CAPS support for research on soil and water resources has gone to research on fertilizers. Because many developing countries have their own deposits of phosphatic rock, the International Fertilizer Development Center (IFDC), with CAPS support, has carried out research based at CIAT to assist Latin American countries to characterize and test their various phosphatic rock deposits. The results have shown that many of these rocks, when finely ground, can be used without further treatment

on the acidic oxisols and some of the ultisols in Latin America. Crop yield can be increased both immediately and for several years after treatment. This technology is now being exploited commercially in Colombia, and will probably be adopted by several other Latin American countries that have phosphatic rock deposits.

CAPS has supported IFDC in a similar project in Mali, which has also shown that finely ground local phosphatic rock can be used directly on the soils of that country. Based on this and other related research, CAPS has funded IFDC to establish a network on rock-phosphate research covering 11 West African countries.

As part of the Program's expanding focus on developing sustainable agricultural production systems, CAPS will increase its support of soils and soil-related research over the next few years. Research on fertilizers, both organic and inorganic, will continue to receive priority but other initiatives, especially in the areas of soil tillage and soil conservation, will also receive greater attention.

Research Management

CAPS reserves a small portion of its budget (1–2%) to support activities that do not fall within the other subprogram. In particular, projects intended to strengthen research management are funded from this source. Inadequate management frequently limits research efficiency and effectiveness in many parts of the world. Initiatives that aim to strengthen various aspects of research

management — from setting priorities to daily administration of projects and reporting results — are funded, often in collaboration with other programs and divisions of IDRC. Special attention is given to management systems to encourage and improve the effectiveness of multidisciplinary research, particularly in an on-farm context.

Conclusions

In view of the increasing food deficit in many developing countries and the fact that at least 800 million people continue to be malnourished, more than half of them to a serious degree, there is absolutely no room for complacency in the field of agricultural research and development. Although it may be argued that people are malnourished more because of poverty and political ineptitude than because of an overall food shortage in the world, the fact remains that the world is moving into an increasingly dangerous situation of imbalance between ample supply in comparatively few countries and increasing need in many others.

IDRC believes that its philosophy of encouraging national scientists to conduct their own research to solve their own problems continues to be the most rational and effective approach. Every effort is made to ensure that the programs that AFNS supports are well adapted to the regions and countries where they operate.

Nevertheless, one must continue to evaluate all projects rigorously to assess their cost effectiveness and their potential long-term impact. One of the strengths of IDRC is its flexibility. CAPS is ready to respond to new needs and initiatives when and where these appear and to shift the emphasis of its support as necessary.

Although many projects require support for relatively long periods, a number of the early projects in CAPS have now been handed over to national governments or to larger donors, mostly upon successful attainment of their objectives. Future years are likely to see a wide range of new opportunities, CAPS will take care to ensure that its resources are used to maximum effect for the benefit of its primary target: poor rural populations throughout the developing world.

Other Programs of AFNS

Agricultural Economics

The Agricultural Economics Program was created in 1984. It is concerned with the production, distribution, and consumption systems in which rural households function. The three research areas identified for support are

- Natural resource production and utilization systems;
- Technology introduction to increase the efficiency of the practices used to introduce technology; and
- Resource allocation in agricultural research, which concentrates on improving research management and organization.

The emphasis is on projects that are an integral part of the research program of an institute that will become directly involved in the generation and dissemination of technology. Many of these projects complement, or are joint activities with, other programs of IDRC.

Fisheries

The primary objective of the Fisheries Program of AFNS is to support research on fish production that will benefit the poor. In the 1970s, it became apparent that most resources of wild fish were already exploited at near-maximum sustainable level. This situation has led the Fisheries Program to give priority to artisanal fisheries and aquaculture.

Artisanal fisheries employ some 20 million people worldwide and provide an important part of the total animal-protein supply in large areas of the developing world. Research problems include assessment of potential yields of natural stocks, efficient management systems to ensure that sustainable yields are not exceeded, and improved post-harvest techniques to bring maximum benefits from available resources to consumers.

Because artisanal fisheries vary in nature and importance from one region to another, research support is regionally flexible. Marine artisanal fisheries are emphasized in Latin America and the Caribbean whereas inland fisheries are a higher priority in Africa and the Middle East.

Aquaculture is a major area of support in Asia and requests for funding of artisanal fisheries research are limited. Research on reservoir fisheries can be supported in all regions because of its potential for increasing net fish production.

In Asia, the Fisheries Program gives high priority to improving existing aquaculture systems. In Africa and Latin America, where aquaculture is not a traditional practice, research to develop or adapt aquaculture systems for local conditions is a high priority. The Program seeks to promote the transfer of appropriate Asian aquaculture technologies by training African and Latin American students in Asia, encouraging exchange visits by Asian staff, and by joint research on-site wherever possible. Although the emphasis is on producing food for poor populations, research into higher valued species and more intensive production methods may be justified when poor producers benefit.

Social and economic factors often hinder the spread of technically promising systems and the Fisheries Program supports research to overcome such constraints.

Forestry

During the past decade, the importance of forests and trees has been increasingly recognized in many developing and industrialized countries. However, expenditures on forestry research are small and mostly directed to the industrial sector, despite the fact that 80% of the wood harvested in developing countries is used for fuel.

The Forestry Program continues to emphasize integrated rather than industrial forestry and to reflect change in the research needs of the developing world, as well as change in the environment. The aim is to achieve a balanced mix of projects with emphasis on recipients who can be relied on to deliver and disseminate their research results.

Establishing growing trees is a top priority in the dry zones of Africa and South America, where expanding agriculture and the need for fuelwood have lead to destruction of the natural forests. Aside from the selection of the best-suited species, research support emphasizes the development of simple techniques to establish and manage woodlots with village-level implementation.

An interdisciplinary approach is taken in supporting agroforestry research, involving both the Crop and Animal Production Systems and Agricultural Economics programs. In the field of forest-product utilization, research has helped to determine and improve the functional properties of secondary and unknown timber species for their use in construction.

Research support for tree improvement and breeding concentrates on bamboo and rattan in Asia and on propagation methods and cultural techniques for widely used multipurpose species such as *Leucaena*, *Prosopis*, and *Paulownia*.

In the field of environmental forestry, the Program has supported a network of four research projects on shelterbelts in Africa

to measure the effect of trees on the microclimate and the production of food crops.

Post-Production Systems

The Post-Production Systems Program deals with the technology, appropriateness, efficiency, and nutritional implications of post-harvest activities for the benefit of low-income people. It covers a wide range of disciplines including engineering, biochemistry, entomology, nutrition, food science and technology, and economics and marketing.

The broad objectives of the Program are to make more and better food available to poor rural and urban consumers at the same time as augmenting employment and income. Food systems are the focus of the Program rather than specific commodities, technologies, or processes. Main activities are food processing and utilization; nutrition; food handling, drying, and storage; and equipment design, adaptation, and testing.

The Program also aims to strengthen village enterprises in the food and agricultural sectors. High priority is given to promoting and disseminating dehullers in rural milling systems, drying of staple foods and preserving perishable foods such as fish, fruits, roots, and vegetables. In all these sectors, training and institutional development are of considerable importance.

Of special concern to the Program is improving nutrition for low-income consumers, especially for such vulnerable groups as young children and pregnant and lactating women. Emphasis will continue to be on access to and supply of appropriate and acceptable foods for these groups. Close collaboration with the Health Sciences and Social Sciences divisions of IDRC on related activities is encouraged.

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